3D MODELING OF EQUATORIAL SPREAD F

J.D. Huba
Plasma Physics Division
Naval Research Laboratory
Washington, DC 20375

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Collaborators: G. Joyce* and J. Krall

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*deceased

THE BEGINNING

Booker and Wells, *J. Geophys. Res. 43*, 249 (1938)

SCATTERING OF RADIO WAVES BY THE *F*-REGION OF THE IONOSPHERE

By H. G. Booker and H. W. Wells

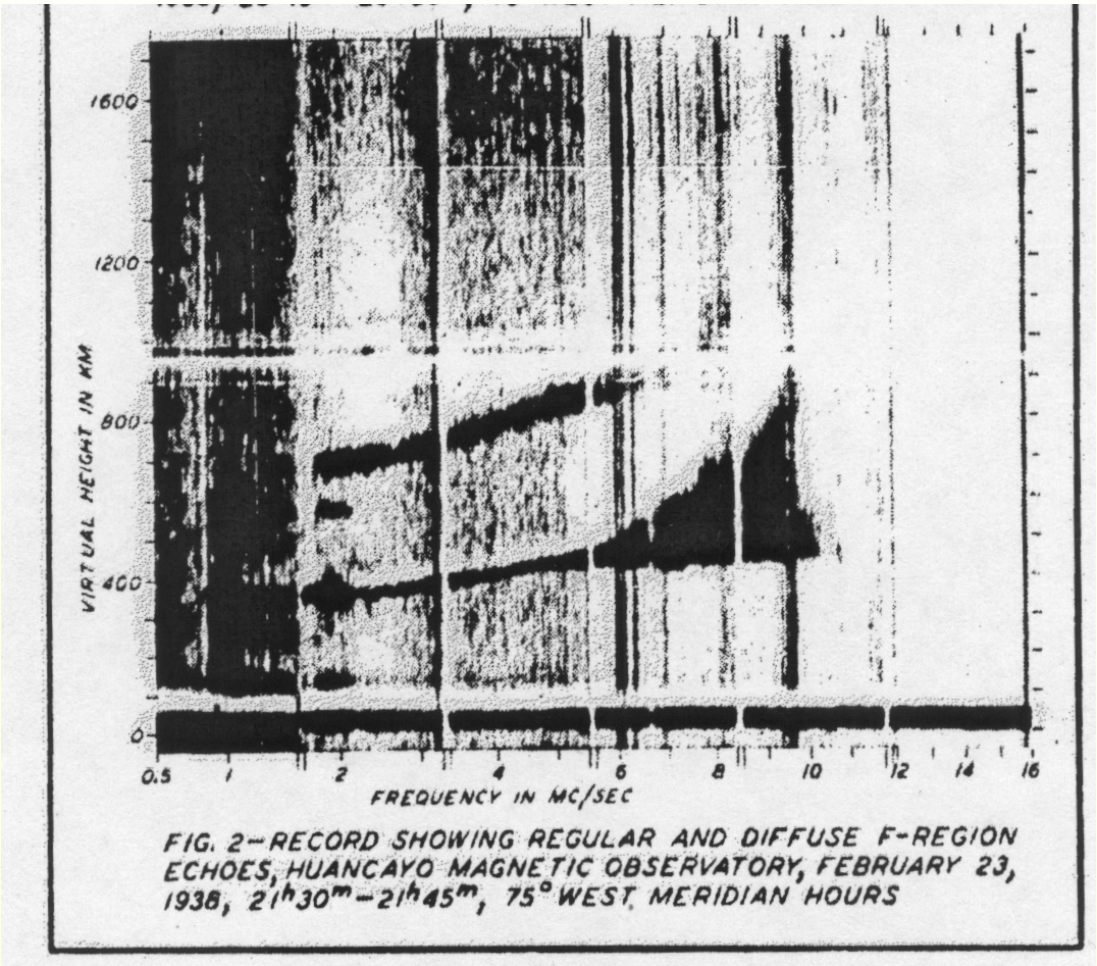
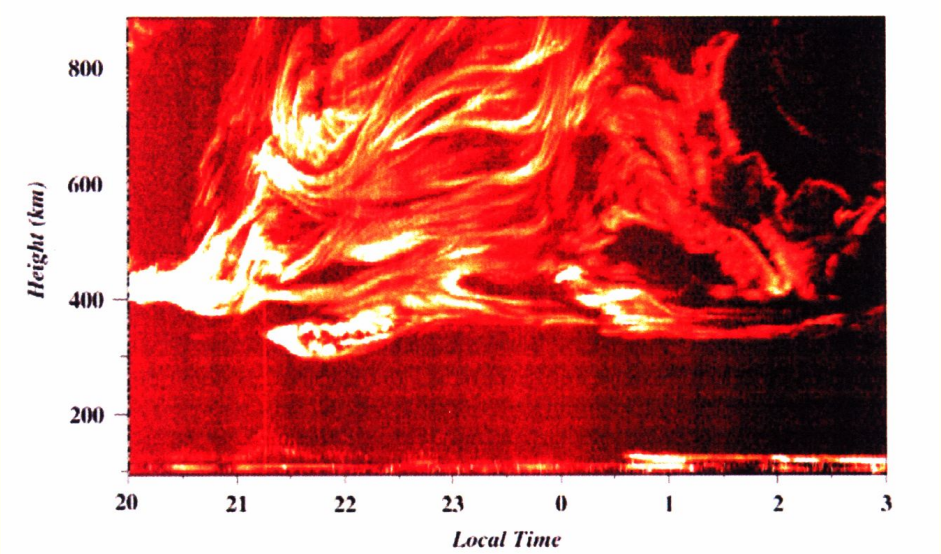
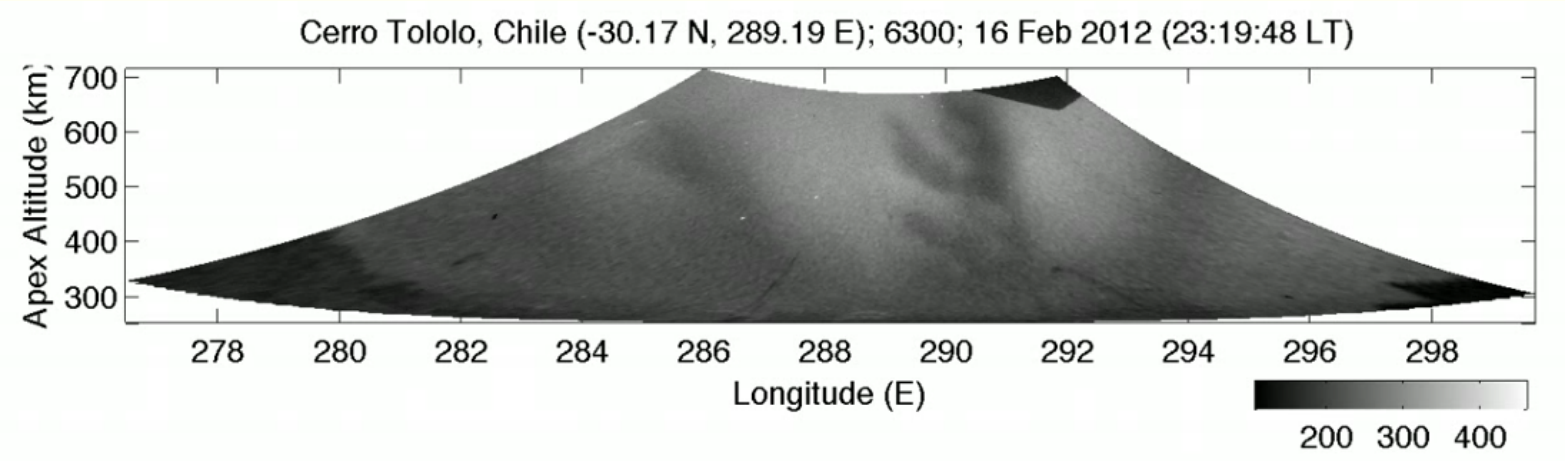


FIG. 2—RECORD SHOWING REGULAR AND DIFFUSE F-REGION ECHOES, HUANCAYO MAGNETIC OBSERVATORY, FEBRUARY 23, 1938, 21^h30^m–21^h45^m, 75° WEST MERIDIAN HOURS

MODERN OBSERVATIONS

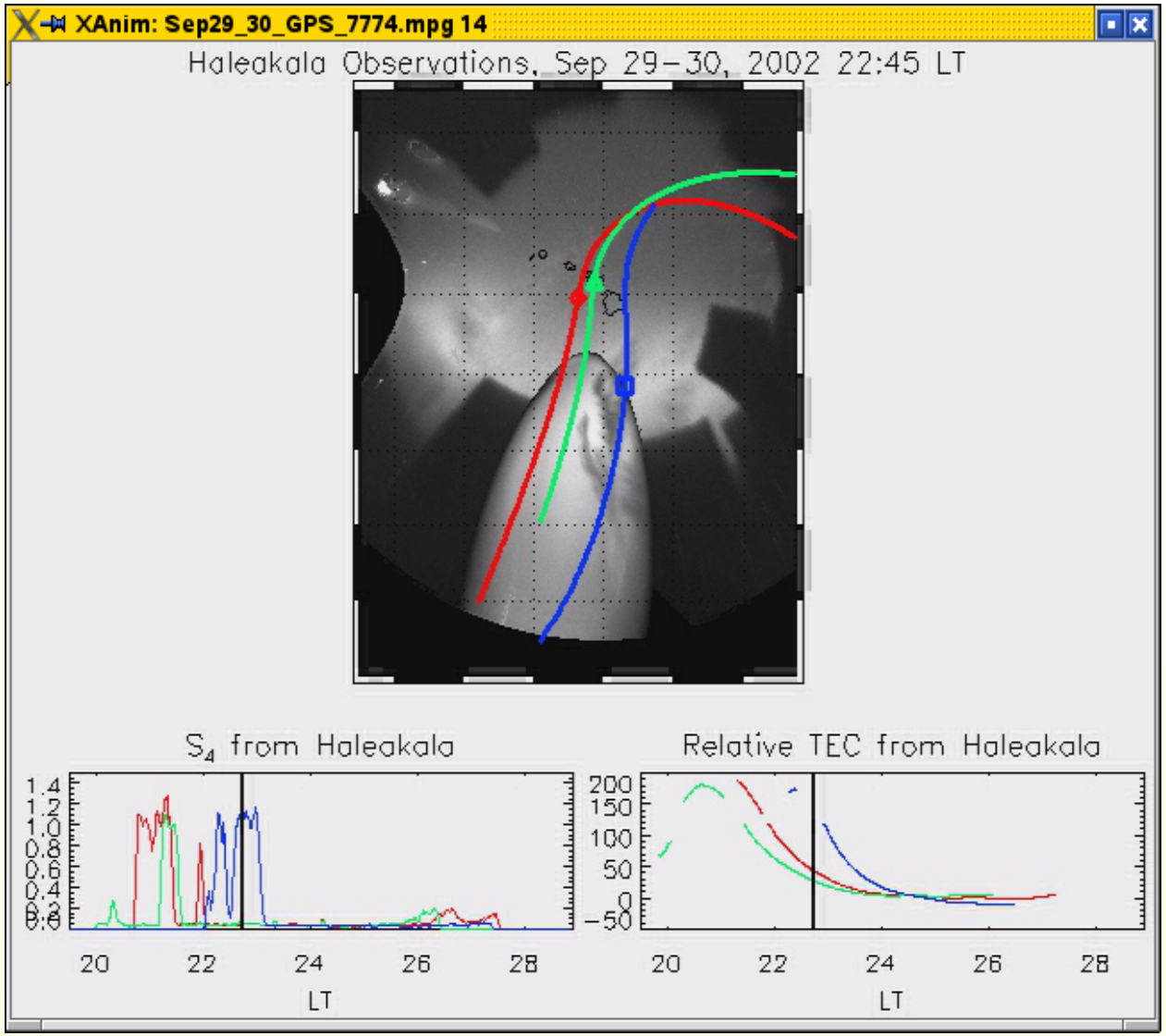
radar backscatter (Hysell) and optical imaging (Makela)





WHY DO WE CARE?

optical and propagation data (Jonathan Makela)



BUBBLE CARTOON

Woodman and LaHoz, *J. Geophys. Res. 81*, 5447 (1976)

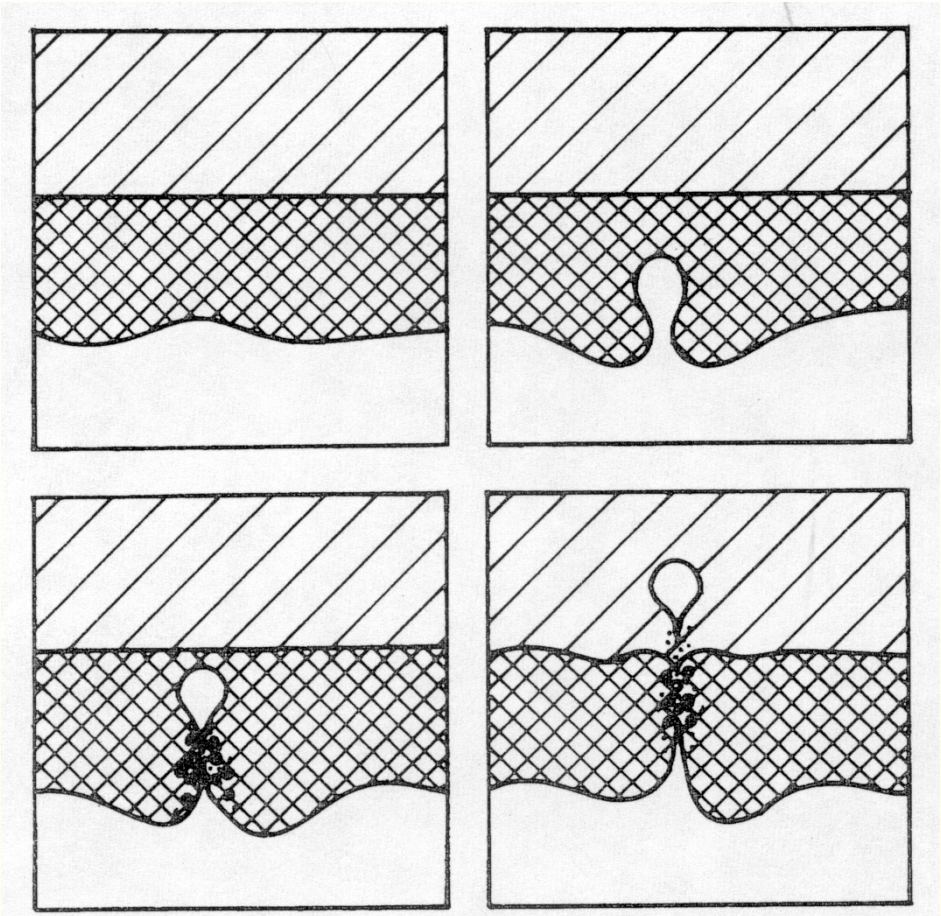
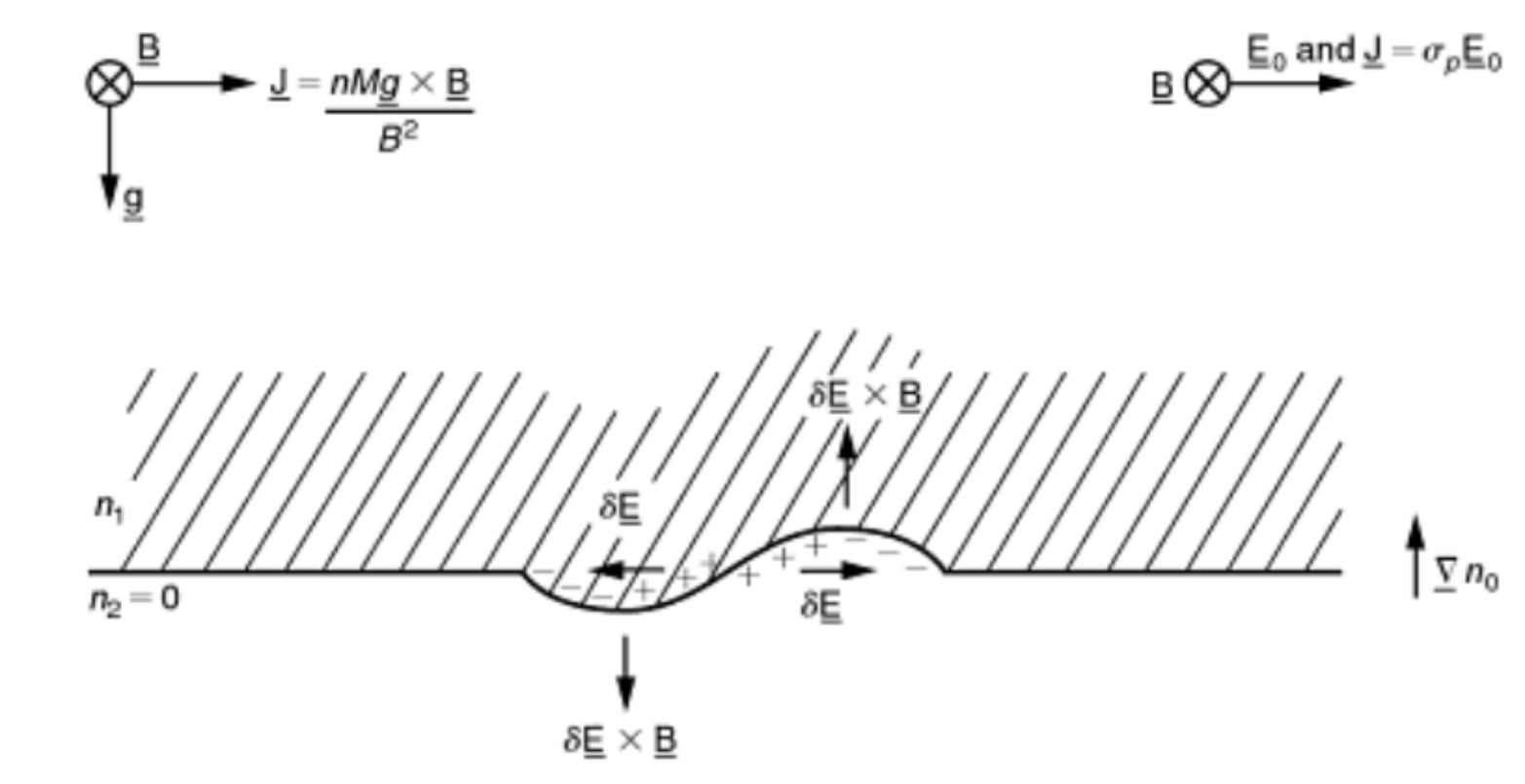


Fig. 9. Schematic representation of a three-density model of the ionosphere showing the formation of a bubble of low electron density and its propagation to the gravitationally stable top. The middle fluid is heavier than the top, and the top fluid heavier than the bottom.

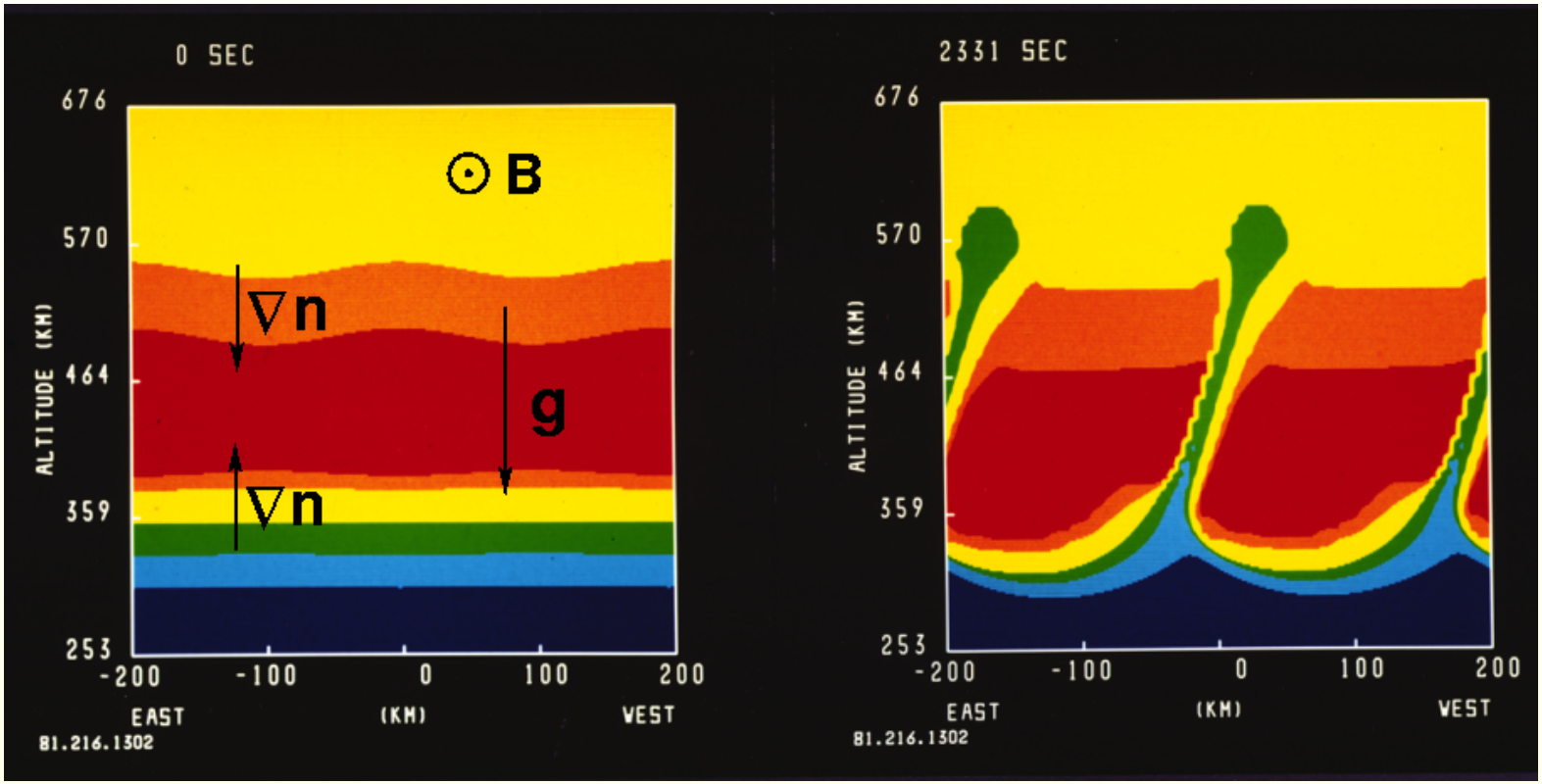
RAYLEIGH-TAYLOR IN THE IONOSPHERE

physical picture (Kelley, Ionosphere Physics, 2000)



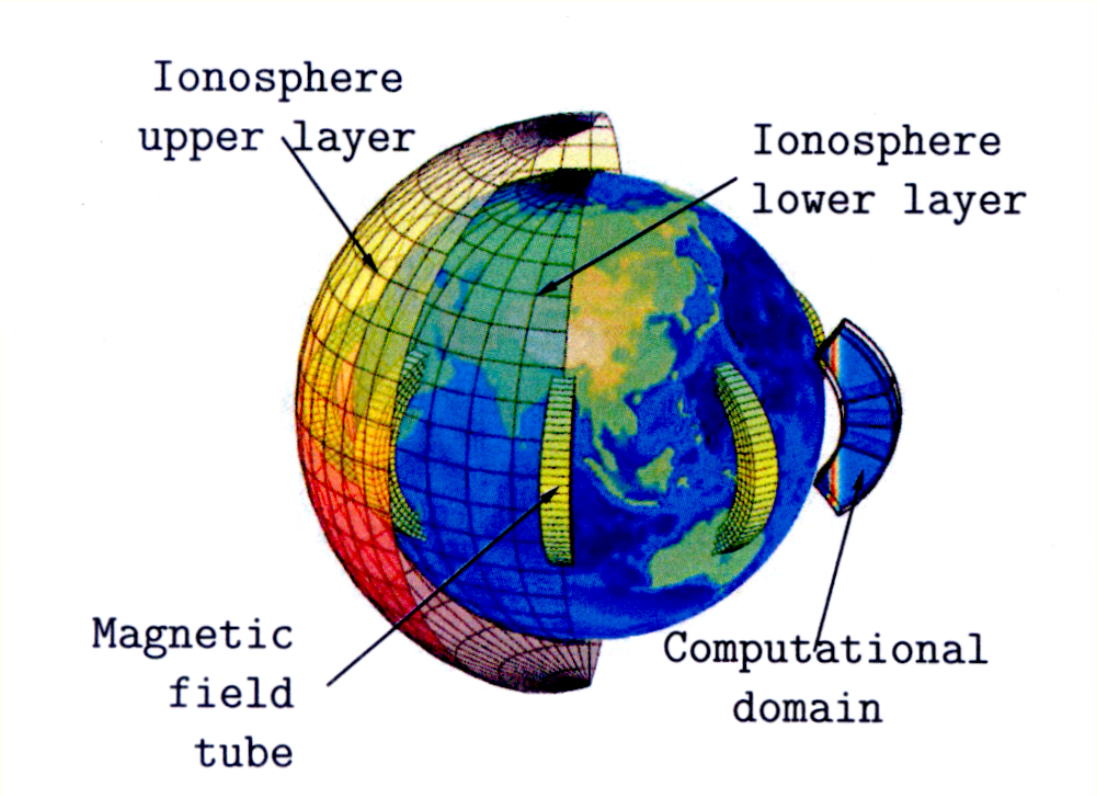
EQUATORIAL SPREAD *F*

2D simulations (Zalesak et al., 1982)



3D ESF WEDGE MODELS

schematic from Besse et al. (2006)

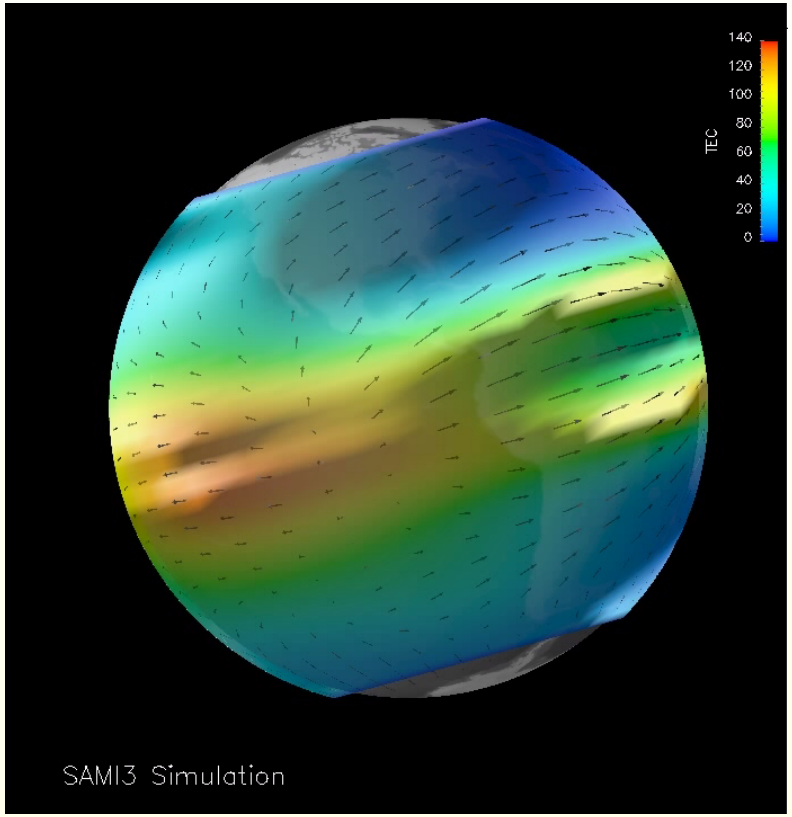


- Huba et al., *GRL*, 2008
- Retterer et al. *JGR*, 2010
- Aveiro and Hysell, *GRL*, 2011

SAMI3 ION DYNAMICS

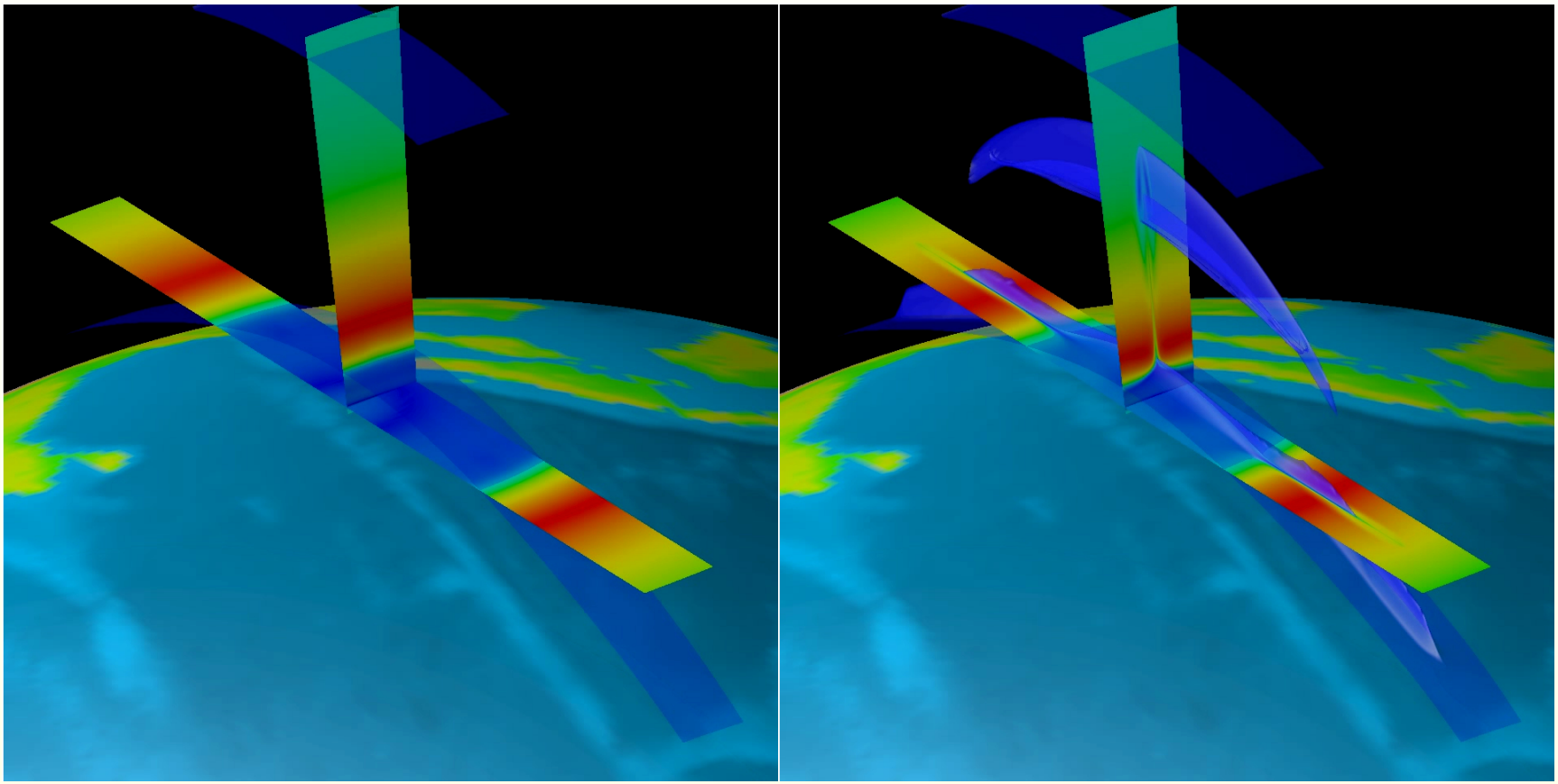
NRL comprehensive ionosphere model

- ions: H^+,O^+,He^+,N^+,N_2^+,NO^+,O_2^+
- interhemispheric model
- vertical and zonal $E \times B$ drift
- neutral species: NRLMSISE00/HWM93
- fully parallelized using MPI
- nonorthogonal, nonuniform fixed grid
- solve continuity, velocity, temperature equations



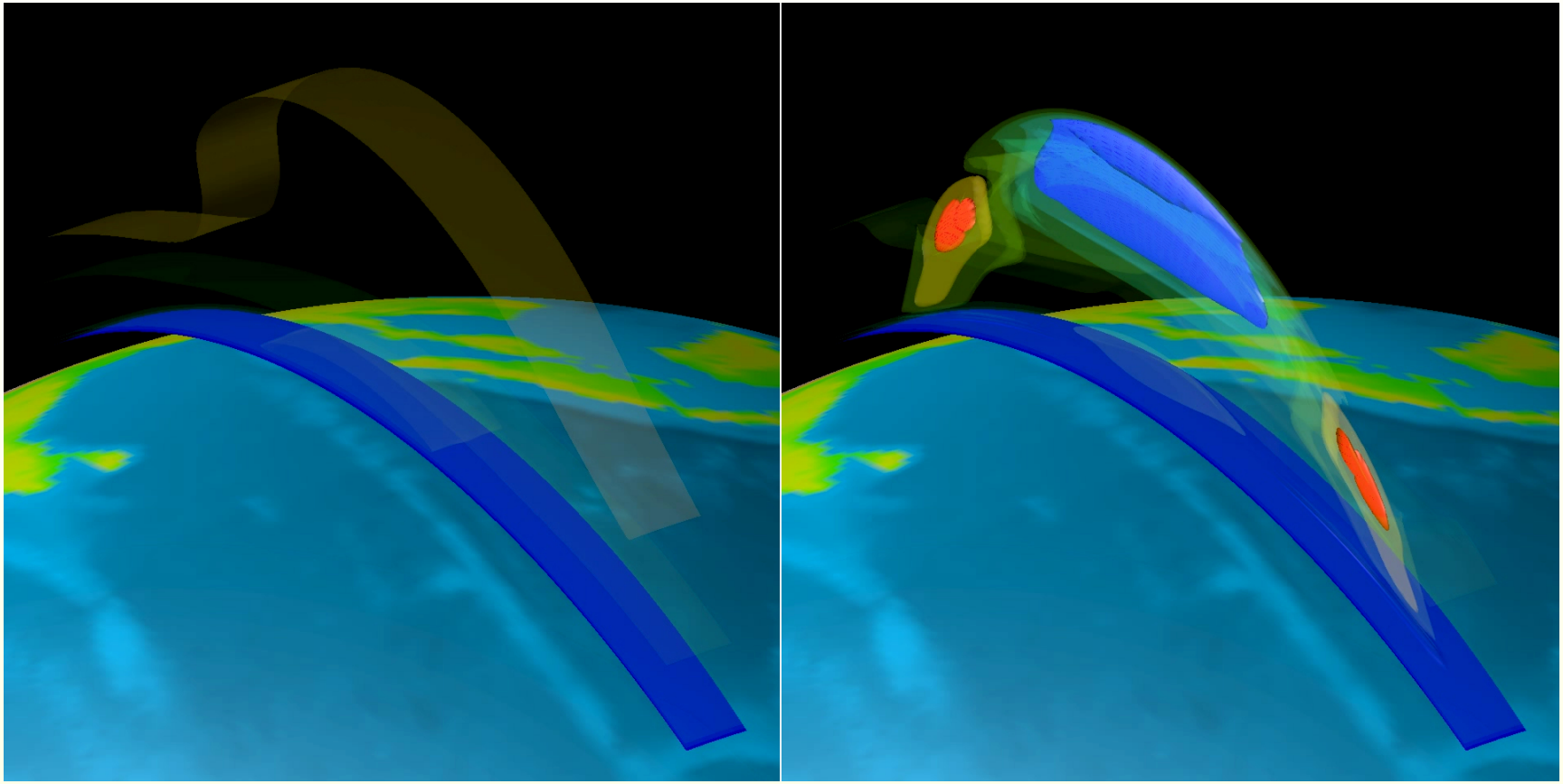
ELECTRON DENSITY

Huba et al., *GRL 36*, L10102, 2009



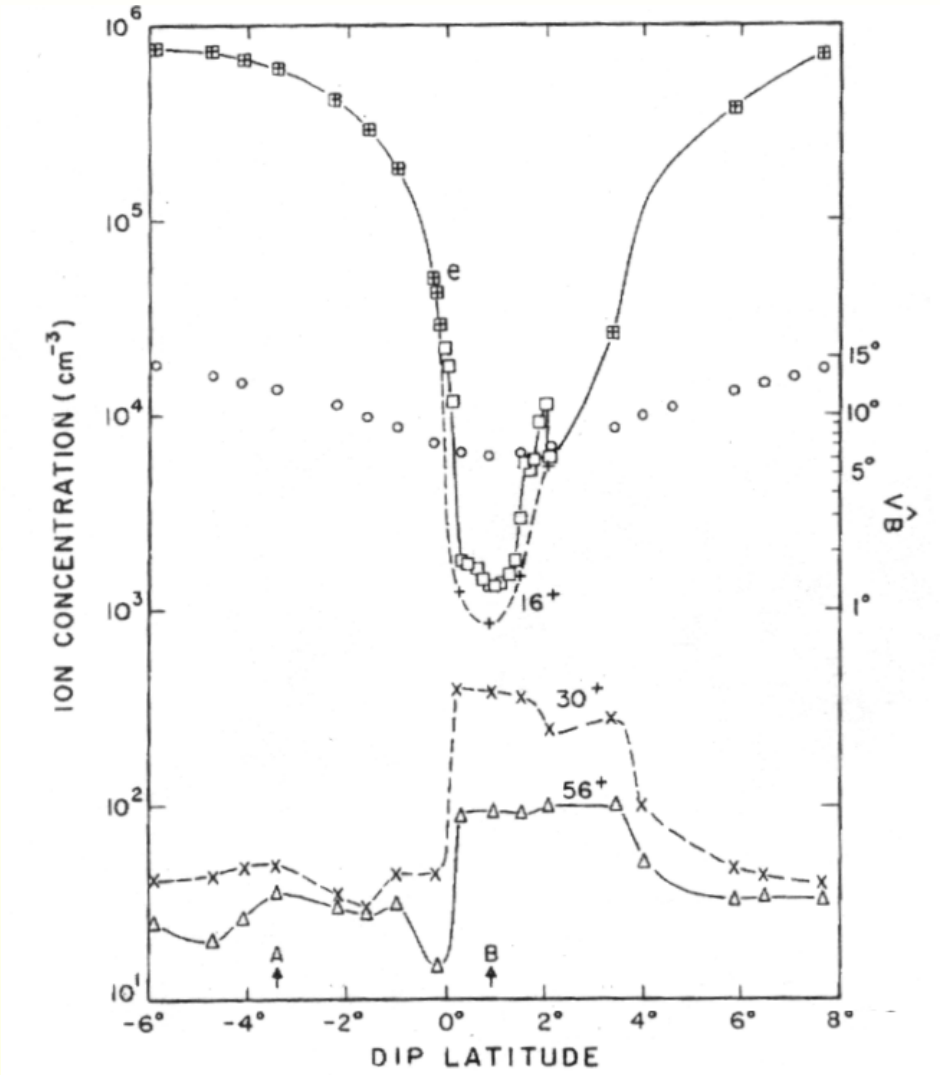
ELECTRON TEMPERATURE

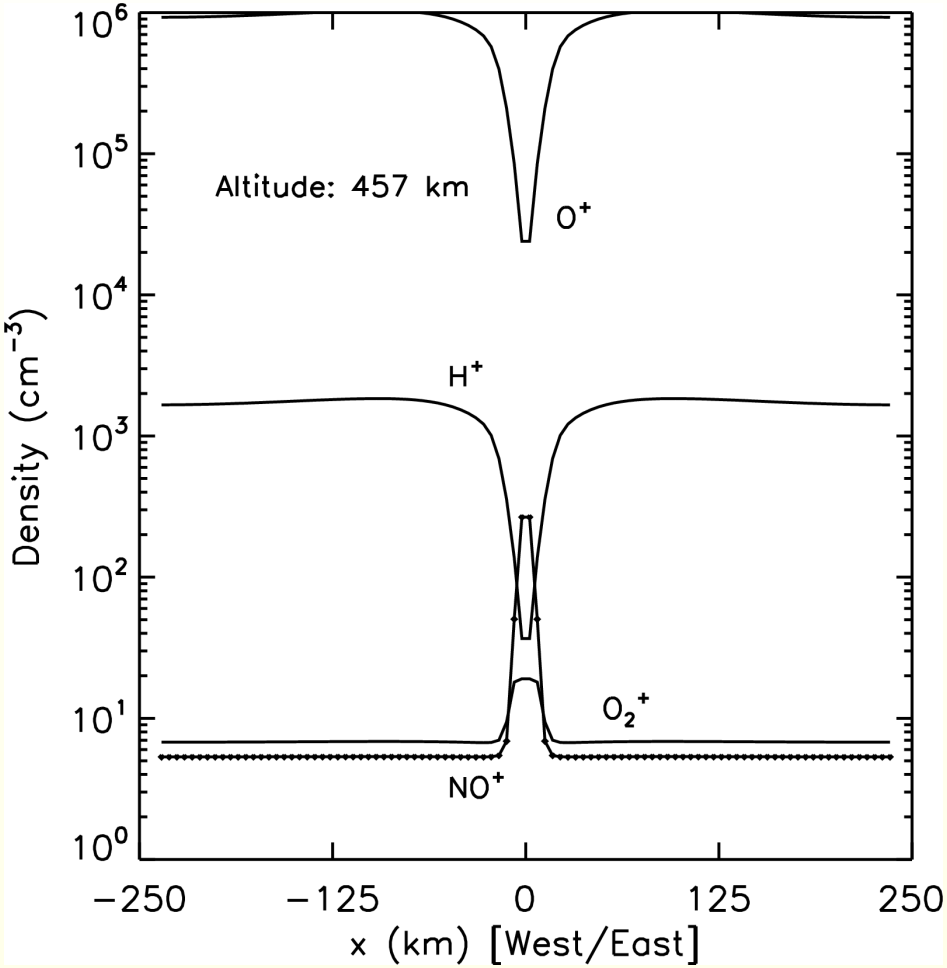
Huba et al., *GRL 36*, L15102, 2009



MOLECULAR IONS

data from Hanson and Sanatani, JGR (1973)

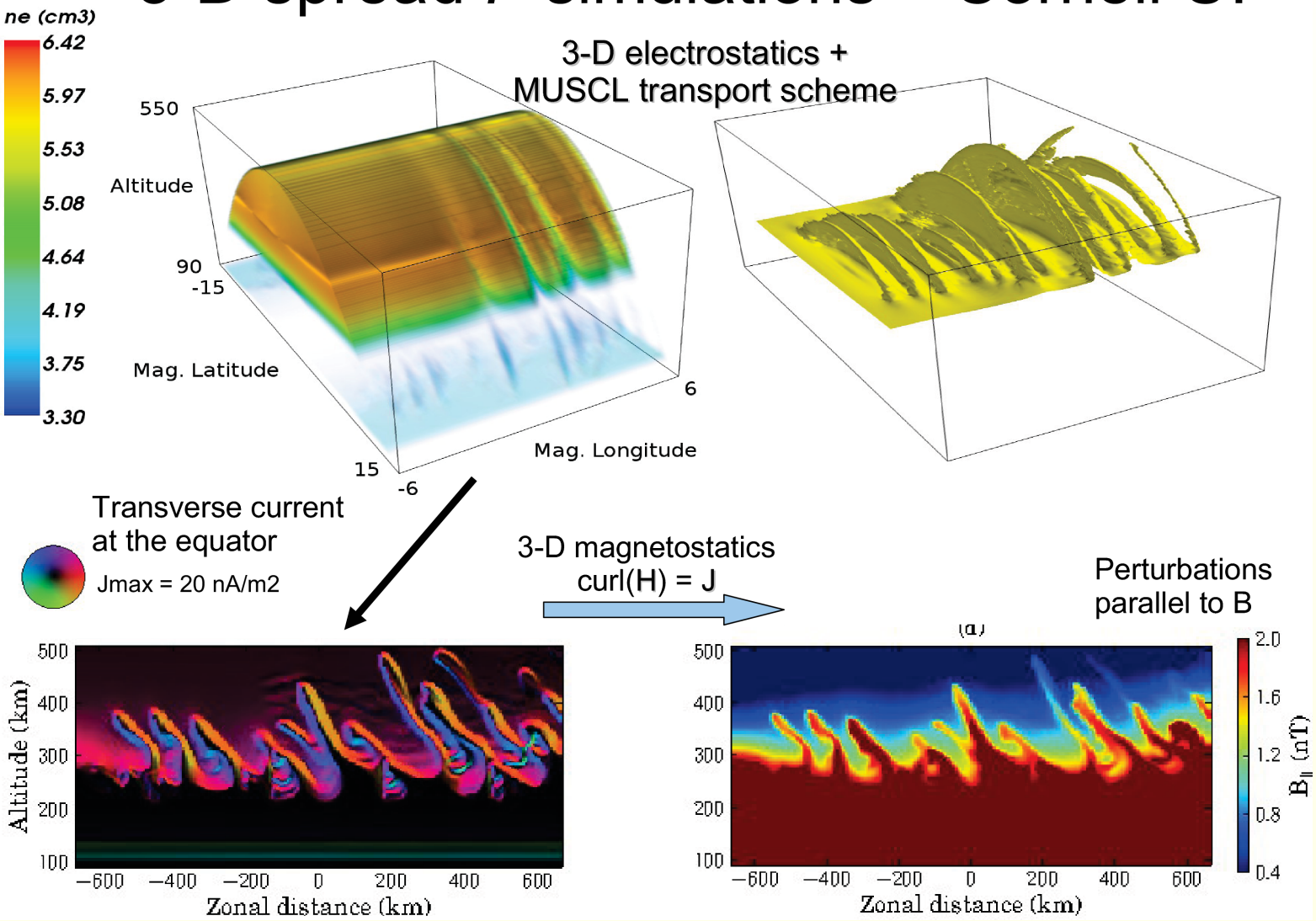




3D ELECTRODYNAMICS

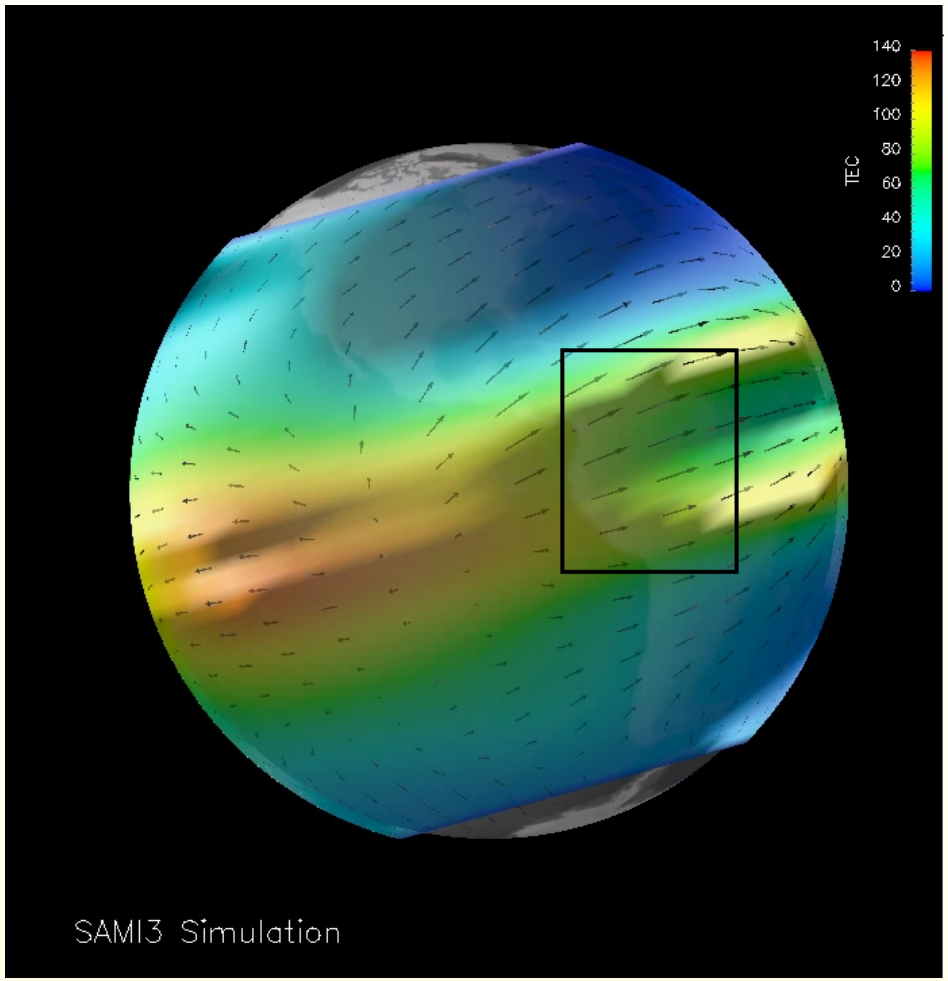
Aveiro and Hysell, *GRL*, 2011

3-D spread *F* simulations – Cornell U.



SAMI3 ION DYNAMICS

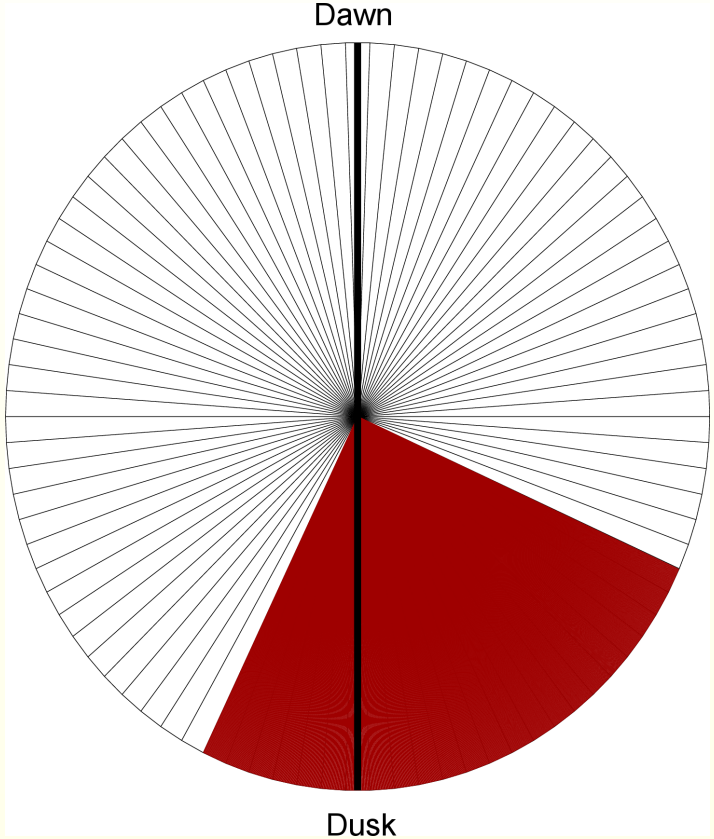
comprehensive ionosphere model with high resolution grid



GLOBAL SOLUTION

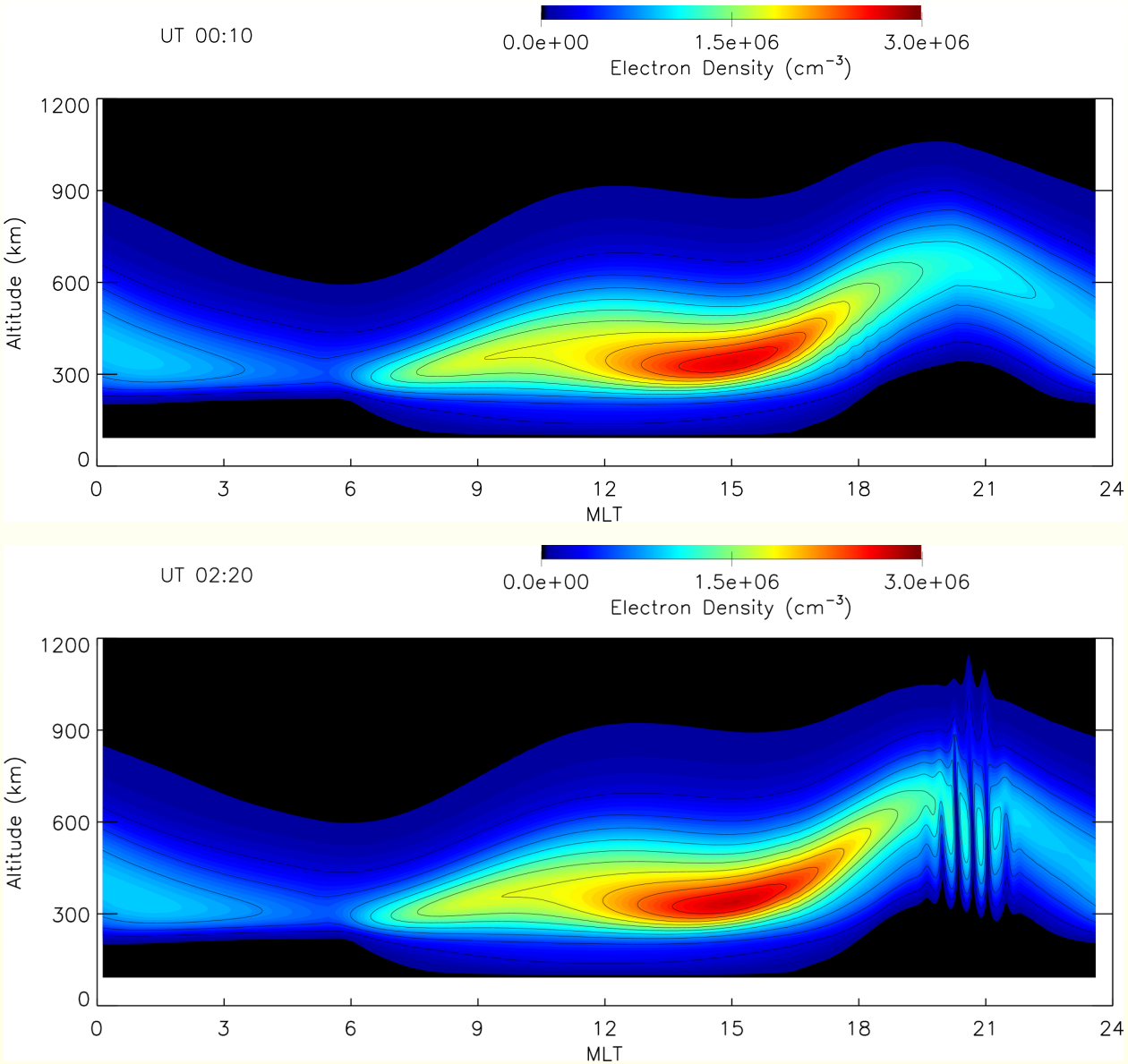
incorporate a high-resolution grid in a global model, i.e., SAMI3

- reference frame: copernican (sun-fixed: rotating earth)
- coarse mesh: 90 grid points
- zonal resolution $\sim$ 500 km
- high resolution mesh: 956 grid points between $\sim$ 16:30 MLT - 22:30 MLT
- zonal resolution $\sim .0625^{\circ}$ or $\sim$ 7 km



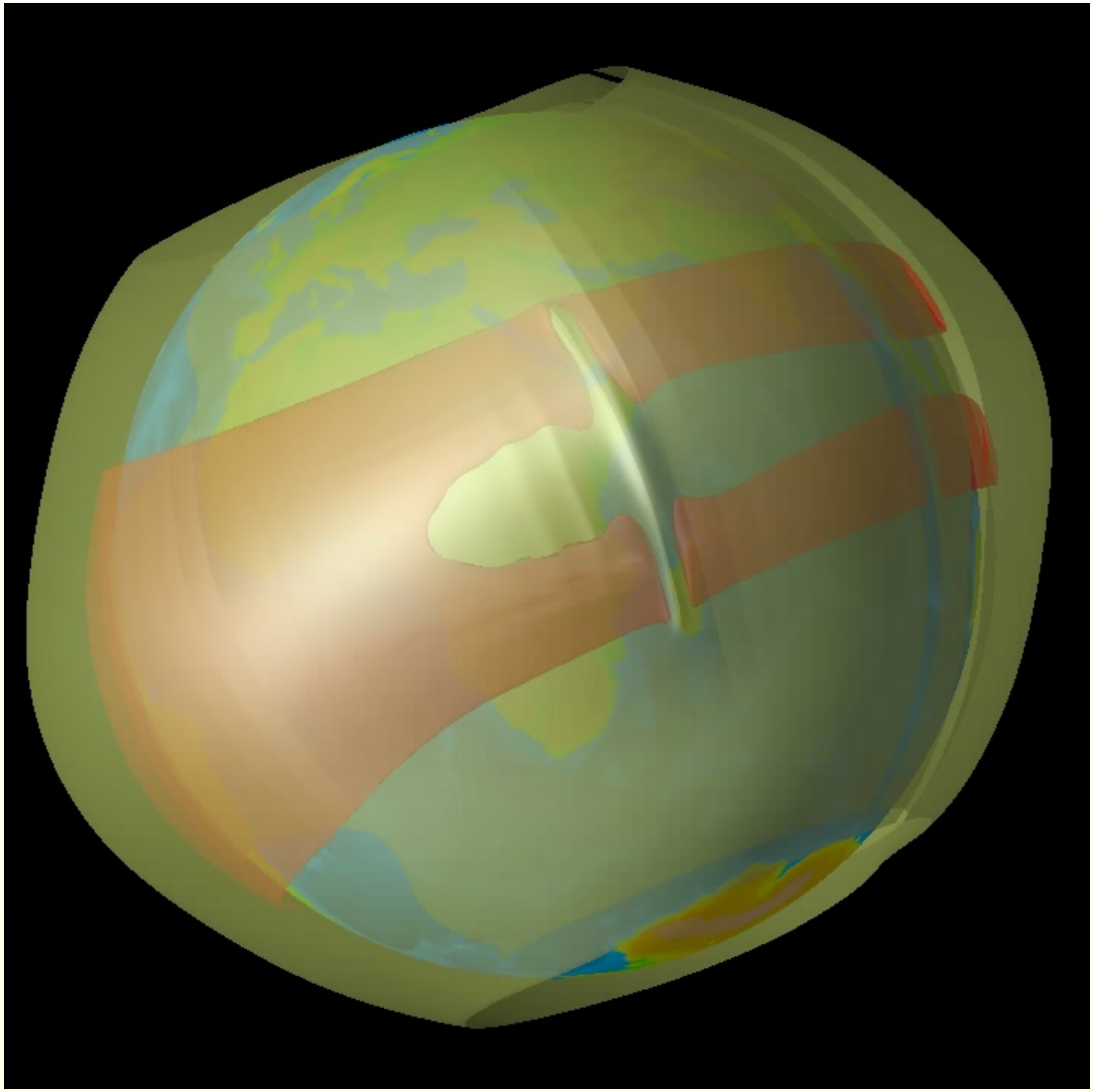
FIRST GLOBAL MODEL OF ESF

Huba and Joyce, *GRL*, 2010



RESULTS

global view of isocontours

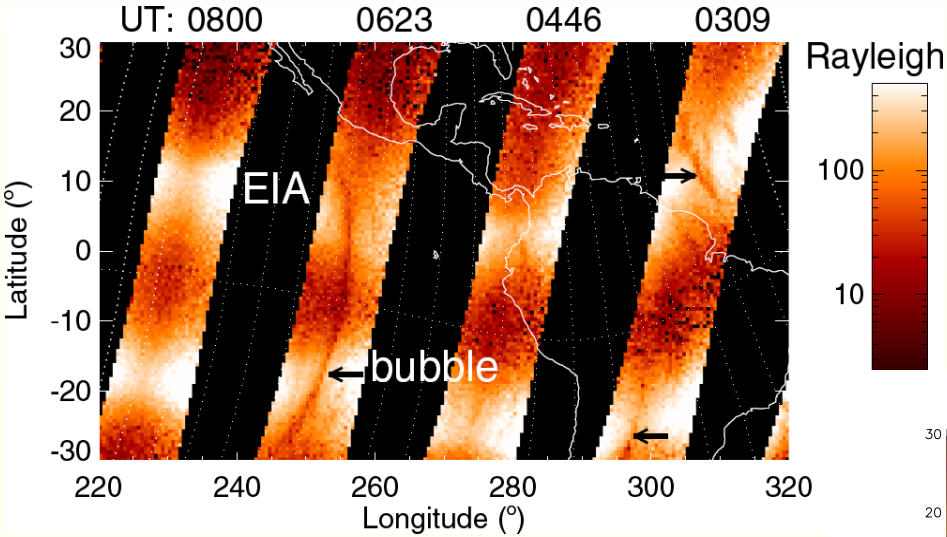


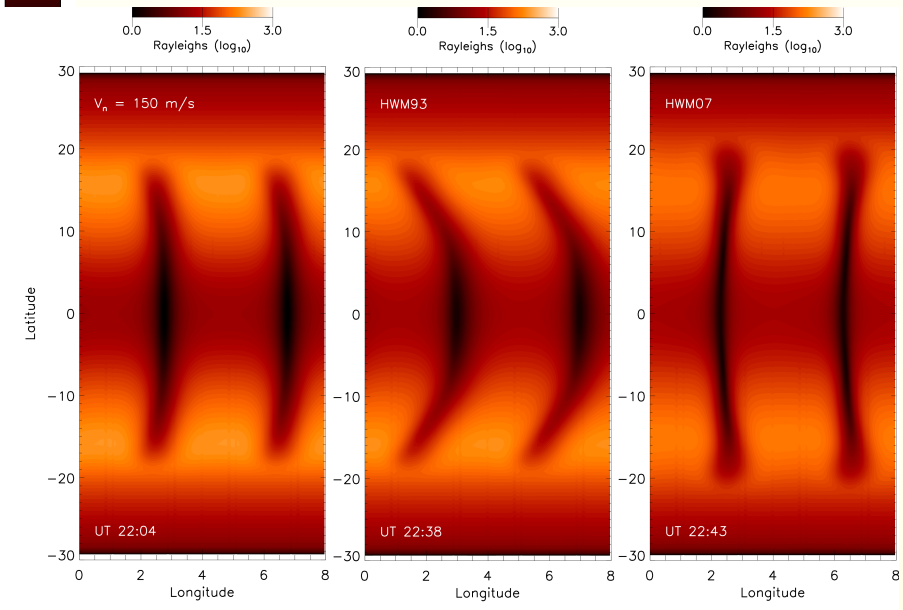
SUMMARY

- considerable amount of research accomplished
  - neutral wind impact: zonal, meridional, vertical
  - associated plasma enhancements
  - travelling ionospheric disturbances
- parameter studies
  e.g., vary perturbation altitude, geophysical parameters, location of high resolution region
- code improvement: high order transport scheme
  e.g., partial donor cell method
- 3D electrodynamics (hysell and aveiro)
- gravity wave seeding (fritts and drob)
- what do we need for forecasting: global neutral wind

IMPACT OF ZONAL NEUTRAL WIND

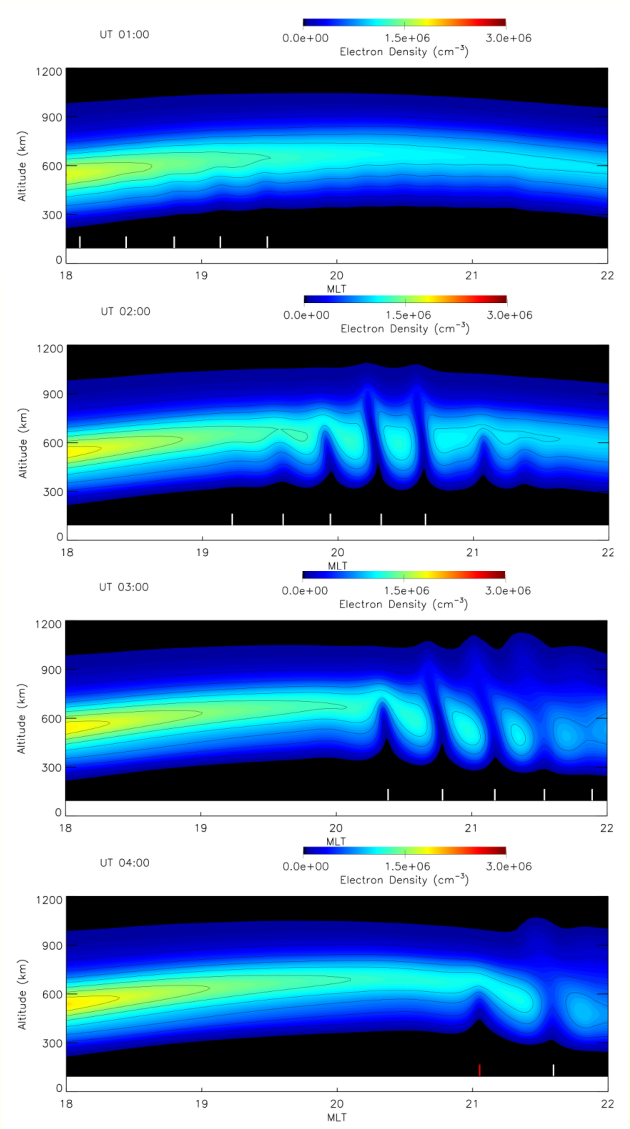
comparison to GUVI data (Huba et al., *GRL 36*, L19106, 200)

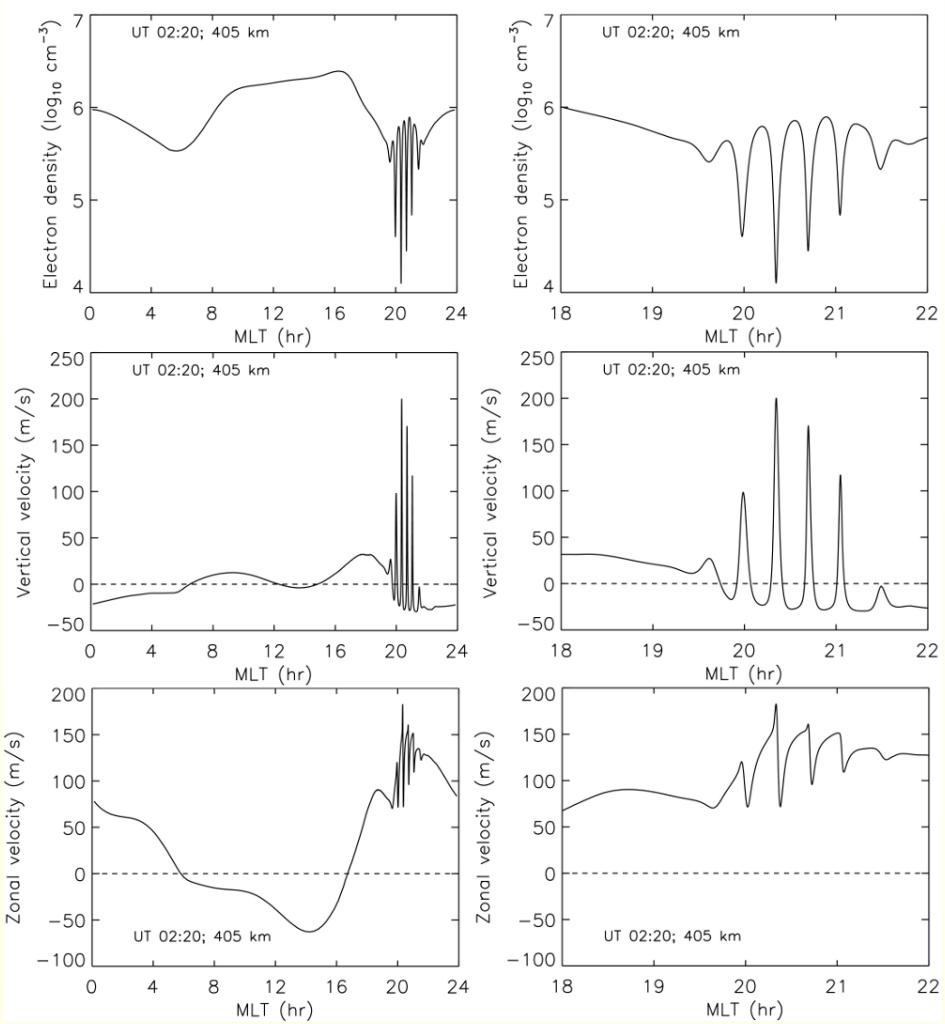




RESULTS

pre-sunset perturbations; one bubble can initiate another





RESULTS

global view of TEC or ‘an infected cat scratch’